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## A Two-stage Retention Débridement Protocol for Acute Periprosthetic Joint Infections

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### Abstract

**Background** Due to the historically poor infection control rates with débridement and component retention for acute periprosthetic infections we developed a new approach for treating acute periprosthetic total joint infections: initial débridement with prosthesis retention and placement of antibiotic-impregnated cement beads followed by a second débridement within 7 days, at which time the beads are removed and new modular parts inserted. Intravenous antibiotics were used for 6 weeks followed by oral antibiotics. Depending on the clinical situation, antibiotics are discontinued or in selected patients continued indefinitely.

**Questions/purposes** We determined the ability of this two-stage débridement to control infection.

**Methods** We retrospectively reviewed the charts of 20 patients who underwent this technique; 2 had postoperative and 18 had hematogenous infections. The primary outcome measure was the infection control. The minimum followup was 1 year (mean, 3.5 years; range, 1.2–7.5 years).

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Each author certifies that his or her institution approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research.

This work was performed at the Mayo Clinic Arizona.

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**Results** Two of the 20 patients had persistent infection. There were no failures in the acute postoperative group (0 of 2) and two of 18 in the acute hematogenous group. Of the 18 patients without evidence of persistent infection, 10 were no longer on antibiotics at the most recent followup and eight were treated with long-term antibiotics due to compromised host status.

**Conclusions** The control of infection in 18 of 20 patients using this technique compares favorably with historical success rates, which range from 24% to 100%. Further research is required to analyze the individual contribution of débridement technique, the use of serial débridements, local depot antibiotics, and combination antibiotic therapy on short-term infection control rates and the long-term persistent control of periprosthetic infection.

**Level of Evidence** Level IV, therapeutic study. See the Guidelines for Authors for a complete description of level of evidence.

### Introduction

Numerous factors influence the treatment outcomes of periprosthetic infections; however, infection duration, host status, and organism are the most important variables in predicting outcomes [5, 6, 15, 16].

Periprosthetic infections can be considered as four types based on duration and interval from the index procedure [7, 27]. Early postoperative infections are usually seeded intraoperatively, although they can also be caused by hematogenous spread, and present within 4 weeks of the index procedure. Acute hematogenous infections are characterized by an acute presentation in a previously well-functioning joint arthroplasty and may be associated with a documented or suspected bacteremia. Late chronic

infections are those that present indolently 1 month or more after the index arthroplasty. They are usually low-grade infections thought to originate perioperatively. From the perspective of treatment and prognosis, late chronic infections also include missed acute infections (early postoperative or hematogenous) that are now greater than 4 weeks in duration. A final group includes patients with positive intraoperative cultures found at the time of revision for presumed aseptic failure [7, 27]. In addition, a staging system for periprosthetic infections has been developed that incorporates the aforementioned infection classification system with the status of the host, including both systemic and local compromising factors [5, 6, 15, 16].

Historically, débridement with component retention has had highly variable, but generally poor infection control rates. A meta-analysis of 530 patients treated for periprosthetic knee infections from 1966 to 2001 revealed an infection control rate of 33% [24]. However, these data include many cases in which the infection onset to débridement interval was not specifically reported and/or was greater than 4 weeks (chronic). Numerous studies report the infection control rates of débridement with component retention are superior when this interval is less than 28 days [3, 8, 11, 17, 22, 28]. A brief review of the literature reveals at least 15 studies have been published since 1990 that report results of débridement with component retention for infections with a duration of approximately less than 28 days [3, 4, 8, 9, 11, 12, 14, 17, 19, 21–23, 27–29] (Table 1). The cumulative results of these studies reveal the infection control rate was 155 of 284 (55%) (range, 24%–100%). These papers include only one level I study, a randomized, controlled trial showing rifampin-combination therapy to be superior to treatment with vancomycin or ciprofloxacin alone for the treatment of acute, implant-associated staphylococcal infections [29].

In an attempt to improve infection control rates of débridement with component retention procedures, we developed a technique to treat acute periprosthetic infections consisting of a two-stage open débridement with prosthesis retention, performed within 7 days of each other, with the placement of antibiotic-impregnated cement beads at the first débridement. We presumed the infection control rate of this technique would be superior to historical results of single-stage débridement with component retention.

We therefore determined (1) the infection control rate with this technique in patients with acute infections; (2) the number of patients who have discontinued all antibiotics versus those who continue on long-term antibiotic therapy; and (3) the effect of infection duration on the infection control rate.

## Patients and Methods

We retrospectively reviewed all 49 patients treated with this technique by the three senior authors (CB, HC, MS) since its implementation in 2002. A historical control derived from peer-reviewed reports of infection control rates of acute periprosthetic infections was used for comparison (Table 1). We identified potential patients by a search of our institutional orthopaedic procedure database. We then assembled a list of all 49 patients who had undergone an arthroplasty-related procedure involving beads by one of the three senior authors since 2002. We included patients when (1) diagnostic criteria for periprosthetic infection were met (Table 2) [10, 18, 20, 25]; (2) infection onset to débridement interval was less than 28 days; (3) initial treatment consisted of a two-stage débridement using antibiotic-loaded cement beads and retention of metallic components; (4) components were mechanically stable at the time of débridement; (5) we had a minimum followup of 1 year beyond the discontinuation of all antibiotics or, for those treated with ongoing prophylactic suppressive antibiotics, minimum followup of 1 year from the time of the initial surgical débridement. We excluded 29 patients with (1) prior history of periprosthetic infection in the involved joint ( $n = 11$ ); (2) late chronic infections (including those with a symptom onset to débridement interval of greater than 28 days) ( $n = 8$ ); and (3) metallic components removed at the initial débridement ( $n = 0$ ). We also excluded six patients with inadequate followup, and four who did not meet the diagnostic criteria for periprosthetic infection. This left 20 infections in 20 patients. There were 16 infected knee arthroplasties and four hip arthroplasties. All of the knee arthroplasties had been implanted using cement. The average patient age was 67 years (range, 28–91 years). Fifteen of the 20 patients met diagnostic criteria for infection with at least two positive cultures for the same organism and antibiotic sensitivity profile at the time of débridement. The remaining five patients met criteria with a combination of two or more of the remaining diagnostic criteria (Table 2), including three patients with gross pus in the joint and a positive synovial fluid cell count, one patient with gross pus in the joint, a positive synovial fluid cell count, and a positive frozen section, and one patient with a positive synovial fluid cell count and elevated inflammatory markers. Of these five patients, two received antibiotics prior to aspiration and culture, potentially contributing to their negative cultures. The minimum followup of the 20 patients was 1.2 years (mean, 3.5 years; range: 1.2–7.5 years). No patients were recalled for followup for this study: we retrieved information either from the charts or telephone calls (see below).

**Table 1.** Historical results for retention débridement of acute periprosthetic infections

Author	Year	Study design	n	Number of infections controlled	Percent of infections controlled	Type of acute infection	Joints Treated	Maximum infection duration (days)	Surgical treatment	Average duration of parenteral antibiotics (range)	Average duration of oral antibiotics (range)	Number receiving long-term prophylactic oral antibiotics	Mean f/u (years)	Min f/u (years)	Max f/u (years)
Schoifet and Morrey [22]	1990	retrospective	21	5	23.8%	postoperative & hematogenous	TKA	28	open débridement	4 wks (9–48 days)	51 days (3–365 days)	none	8.8	3	12
Rasul et al. [21]	1991	retrospective	7	3	42.9%	postoperative & hematogenous	TKA	21	open débridement with placement of antibiotic cement beads for 1–3 wks	4–6 wks	not mentioned	not mentioned	2	7	
Burger et al. [3]	1991	retrospective	23	7	30.4%	postoperative & hematogenous	TKA	28	open débridement	5 wks (2–8 wks)	not mentioned	not mentioned	3.5	2.5	4.8
Hartman et al. [11]	1991	retrospective	33	13	39.4%	postoperative & hematogenous	TKA	28	open débridement	5.5 wks (2–12 wks)	unknown	unknown	4.5	2	9
McLaren and Spooner [14]	1996	retrospective	4	4	100.0%	not mentioned	TKA	35	open débridement with placement of antibiotic-loaded cement, return to OR for repeat I&D, bead removal at 3 weeks	6 wks	6wks	none	1.5	1.5	1.5
Wasilewski et al. [28]	1996	retrospective	8	6	75.0%	postoperative & hematogenous	TKA	14	open débridement	6 wks (3–12 wks)	varied from "none to indefinite"	not mentioned	~2.7	2	
Tsukayama et al. [27]	1996	retrospective	41	28	68.3%	postoperative & hematogenous	THA	28	open débridement	4–6 wks	none	none	2	6.7	
Mont et al. [19]	1997	prospective	24	20	83.3%	postoperative & hematogenous	TKA	29	1–3 open débridements (knee cultured within 2 weeks; repeat débridement performed if cultures were positive)	6 wks	none	none	4	2	12
Zimmerli et al. [29]	1998	randomized controlled trial	8	8	100.0%	postoperative & hematogenous	THA & TKA	21	open débridement	2 wks	3–6 mo	none	2		
Crockarell et al. [8]	1998	retrospective	23	6	26.1%	postoperative & hematogenous	THA	32	open débridement (entire study group (including chronic infections) received an average of 2.2 débridement, range 1–17)	4 wks (2–72 days)	(0–376 days)	2	7.6	3.2	22

**Table 1.** continued

Author	Year	Study design	n	Number of infections controlled	Percent of infections controlled	Type of acute infection	Joints Treated	Maximum infection duration (days)	Surgical treatment	Average duration of parenteral antibiotics (range)	Number receiving long-term prophylactic oral antibiotics	Mean f/u (years)	Min f/u (years)	Max f/u (years)	
Segawa et al. [23]	1999	retrospective	17	10	58.8%	postoperative & hematogenous	TKA	28	open débridement with placement of antibiotic-loaded cement beads; 2 wks later beads removed through minimal incision.	4–6 wks	not mentioned	~3.5	2	8.8	
Mehan et al. [17]	2003	retrospective	19	17	89.5%	hematogenous	THA & TKA	10	open débridement	4 wks	variable	8	6.1	1.2	21.8
Deirmengian et al. [9]	2003	retrospective	31	11	35.5%	postoperative & hematogenous	TKA	28	open débridement	6 wks	not mentioned	5	4	2	10
Ilahi et al. [12]	2005	retrospective	5	5	100.0%	hematogenous	TKA	5	open débridement	6 wks	2–4 wks	none	3.4	3	3.6
Chiu and Chen [4]	2007	prospective	20	12	60.0%	postoperative & hematogenous	TKA	28	open débridement	at least 6 wks	none	none	6.6	3.2	11.9
Estes et al. [current study]	2009	retrospective	20	18	90.0%	postoperative & hematogenous	THA & TKA	16	two-stage open débridement with antibiotic-loaded cement beads placed at first debridement	6 wks	9 mo	8	3.5	1.2	7.5

Author = First author of study; n = number of acute infections treated with retention débridement; THA = total hip arthroplasty; TKA = total knee arthroplasty; wks = weeks; f/u = followup.

**Table 2.** Diagnostic criteria for periprosthetic infection

Criteria
(1) Any patient with 2 or more positive cultures for the same organism with the same antibiotic sensitivity profile
(2) Any patient meeting 2 or more of the following:
(a) Gross pus in joint/communicating sinus tract
(b) Positive synovial fluid cell count ( $> 2000$ nucleated cells, $> 64\%$ PMNs) without preexisting inflammatory disease [20]
(c) $> 5$ PMNs/hpf on frozen section [18]
(d) Elevated ESR and CRP without preexisting inflammatory disease and $> 2$ months after index procedure [20, 25]

PMN = polymorphonuclear leukocyte; hpf = high-power field; ESR = erythrocyte sedimentation rate; CRP = C-reactive protein.

In an attempt to determine the effect of host status on infection control rate, host status was classified according to the system described by McPherson et al. [15, 16]. This staging system incorporates three factors: (1) infection type (acute postoperative, acute hematogenous, late chronic infection); (2) grade of systemic compromising factors of the host (ie existing medical comorbidities); and (3) grade of local host compromising factors (ie status of the soft tissue envelope).

The treatment protocol consisted of a two-stage open débridement with component retention. Sixteen of the 20 patients underwent débridement within 1 week of symptom onset, two were treated after an interval of 10 days, one after an interval of 12 days, and one at 16 days. Patients were brought to the operating room within 24 hours of presentation. During the Stage I débridement, all modular components were removed and sterilized by flash autoclave or in a betadine soak. At least three tissue cultures were obtained and a thorough débridement was performed. This included a meticulous synovectomy along with exposure of bone-implant interfaces wherever possible (eg, removal of the soft tissue meniscus around the patella, exposure of the peripheral rim of the acetabular component). Bone-implant interfaces were curetted. Screws, if present, in the acetabular component were removed and screw holes curetted. All retained components were scrubbed (some with betadine and others with castile soap irrigation solution). The joint was then irrigated with 6 to 9 liters of castile soap irrigation solution [2] before the sterilized modular components were replaced. Finally, high-dose antibiotic-impregnated cement beads were placed in the joint space (one mix of PMMA [Palacos®, Zimmer, Inc, Warsaw, IN] with 3.6 g gentamicin or tobramycin, 3 g vancomycin, and 2 g cefazolin). Preparation of the beads entailed hand-mixing the polymethylmethacrylate polymer and antibiotic powder, followed by the addition of monomer and continued hand-mixing. While in the dough phase, the cement was fashioned into beads approximately one centimeter in

diameter and strung on a nonabsorbable monofilament suture and allowed to harden prior to implantation. When treating knee infections, the entire volume of cement beads could be implanted in the medial and lateral gutters and in the suprapatellar space. For hip infections, as much of the periprosthetic space as possible was filled with beads. This amount was typically one half to three quarters of the antibiotic-loaded cement batch. The wound was then closed over a 1/8 inch drain (Hemovac®, Zimmer, Inc, Warsaw, IN). Substantial antibiotic elution continues up until the time of bead removal [1] such that we believed the benefit of using a drain outweighed the disadvantage of allowing some of the eluted antibiotics to escape into the drain.

Patients with knee infections were kept in a knee immobilizer brace and allowed out of bed weight bearing as tolerated. Patients with hip infections were allowed out of bed with activities as tolerated. Range of motion was not specifically restricted apart from standard hip position precautions, avoiding extremes of motion. Various venous thromboembolism prophylaxis modalities were employed between stages. Most commonly a combination of mechanical prophylaxis and low molecular weight heparin was used. The patient was returned to the operating room 3 to 7 days later for the Stage II débridement. At this time, the beads were removed, tissue cultures were obtained, a repeat débridement was performed, and new modular parts were inserted. A 1/8 inch drain (Hemovac®, Zimmer, Inc, Warsaw, IN) was again used.

A standard postoperative rehabilitation protocol was implemented for all patients. Patients were mobilized twice per day starting on postoperative day 1 with a front-wheeled walker and supervised physical therapy. Standard hip precautions were enforced for all patients with hip arthroplasties. Walking distance and weight bearing were advanced as tolerated. After discharge from the hospital, approximately 4 weeks of supervised outpatient physical therapy was typically prescribed for those with total knee arthroplasties. However, those with total hip arthroplasties were not routinely sent for outpatient physical therapy. Patients graduated from a walker to crutches or a cane at approximately 3 weeks postoperatively and then allowed to wean themselves from walking assists at their own discretion.

Patients returned for clinical followup at 2 weeks, 6 weeks, 3 months, 1 year and every 1–3 years thereafter. Intravenous antibiotics were employed for 6 weeks. Patients with infections due to *Staphylococcus aureus* and coagulase-negative *Staphylococcus* were usually treated with rifampin-combination therapy for six weeks. Patients were placed on a variable course of oral antibiotics thereafter (average of 9 months) (Table 3). The criteria used to stop the antibiotics were a clinical exam consistent with

**Table 3.** Selected patient information

Patient	Age (years)*	Site	Host variables relevant to staging	Host status†	Index to symptom onset interval (months)	Infection duration (days)	Isolate from preoperative aspiration and/or Stage I debridement	Isolate from Stage II debridement	IV Antibiotics during 6 weeks after débridement	Length of followup (months)	Duration off antibiotics at last followup (months)	Oral antibiotics at last followup	Outcome
1	28	TKA	Leukemia, h/o BMT, immunosuppressive drugs	II-B-1	5.0	1	Cultures negative	Cultures negative	Ceftriaxone	48.4	0	PCN V	Controlled
2	29	TKA	h/o osteosarcoma	II-B-1	114.5	1	Cultures negative	Cultures negative	Vancomycin, ceftriaxone	25	16.6	none	Controlled
3	56	THA	Synovial-cutaneous fistula, prior trauma	I-A-2	0.7	1	MRSA	MRSA	Lincosolid, PO rifampin	83.8	62.9	none	Controlled
4	66	THA	Alcoholism	II-B-1	132.2	2	Cultures negative	No cultures taken	Cefazolin	42.8	43.8	none	Controlled
5	76	TKA	None	II-A-1	11.8	2	Cultures negative	Cultures negative	Penicillin	84.7	72.9	none	Controlled
6	71	TKA	None	II-A-1	14.0	2	MSSA	No cultures taken	Cefazolin, PO rifampin	28.2	18.2	none	Controlled
7	61	THA	None	II-A-1	124.9	2	MSSA	Cultures negative	Ciprofloxacin, PO rifampin	89.4	71.8	none	Controlled
8	72	TKA	h/o lung cancer, multiple myeloma	II-C-1	5.8	3	Streptococcus pneumoniae	Cultures negative	Ceftriaxone	13.8	0	TMP-SMX	Controlled
9	77	TKA	None	II-A-1	9.1	3	Coagulase-negative Staphylococcus	Cultures negative	Cefazolin, PO rifampin	23.5	0	levofloxacin	Controlled
10	80	TKA	Age, h/o prostate cancer	II-B-1	208.0	3	Escherichia coli	Cultures negative	Ceftriaxone	28.3	0	cephalexin	Controlled
11	63	TKA	Chronic lymphedema	II-A-2	55.3	3	MSSA	Cultures negative	Nafcillin, PO rifampin	22.9	0	cephalexin	Controlled
12	70	TKA	None	II-A-1	4.2	4	Group G β-hemolytic Streptococcus	Cultures negative	Ampicillin	56.2	51	none	Controlled
13	85	TKA	Age, alcoholism	I-B-1	0.9	4	Peptostreptococcus and MRSA	Cultures negative	Vancomycin, PO rifampin	46	43.1	none	Controlled
14	70	TKA	DM II, h/o splenectomy	II-B-1	29.9	5	MSSA	Cultures negative	Cefazolin, PO rifampin	23.5	15.6	none	Controlled
15	78	THA	Non-Hodgkin's lymphoma, Sjogren's syndrome, myelodysplasia	II-C-1	10.3	5	Enterococcus faecalis	Cultures negative	Daptomycin	14.5	0	ampicillin	Controlled
16	51	TKA	h/o splenectomy, renal transplant, immunosuppressive drugs,	II-B-1	20.8	7	Escherichia coli	Cultures negative	Ceftriaxone	53.5	0	TMP-SMX	Controlled
17	68	TKA	Non-Hodgkin's lymphoma, metastatic renal cancer, h/o Merkel cell cancer	II-C-1	2.1	10	Streptococcus pneumoniae	Cultures negative	Ceftriaxone, levofloxacin	24.9	0	TMP-SMX	Controlled

**Table 3.** continued

Patient	Age (years)*	Site	Host variables relevant to staging	Host status <sup>†</sup>	Index to symptom onset interval (months)	Infection duration (days)	Isolate from preoperative aspiration and/or Stage I débridement	Isolate from Stage II débridement	IV Antibiotics during 6 weeks after débridement	Length of followup (months)	Duration off antibiotics at last followup (months)	Oral antibiotics at last followup	Outcome
18	73	TKA	None	II-A-1	79.5	10	Cultures negative	Cultures negative	Vancomycin	50.1	48.7	none	Controlled
19	70	TKA	DM II, h/o breast cancer	II-B-2	36.8	12	Streptococcus agalactiae	No cultures taken	Ceftriaxone, gentamicin	—	—	PCN V	Failed
20	91	TKA	Age, rheumatoid arthritis, immunosuppressive drugs	II-C-2	252.3	16	MRSA	MRSA	Vancomycin, PO rifampin	—	—	minocycline	Failed

\* Age at time of Stage I débridement; <sup>†</sup> as defined by McPherson et al. [22, 33]; h/o = history of; BMT = bone marrow transplant; DM II = Type II diabetes mellitus; MSSA = methicillin-sensitive *Staphylococcus aureus*; MRSA = methicillin-resistant *Staphylococcus aureus*; MRSE = methicillin-resistant *Staphylococcus epidermidis*; PO = oral. PCN = penicillin; TMP-SMX = Trimethoprim-Sulfamethoxazole; Infection duration = Symptom onset to débridement interval.

resolution of infection (well-healed wound, decreasing swelling and warm, absence of erythema), a well-functioning joint, and normalization of serum inflammatory markers. If, after discontinuation of antibiotics, the patients were functioning well clinically, inflammatory markers were not routinely obtained. Patients with substantial local or systemic compromise (eg, chronic lymphedema, active malignancy, immunosuppressive therapy for inflammatory disorders or transplant recipients) were often treated with prophylactic long-term antibiotic therapy.

Eleven of the 20 patients were contacted by telephone for additional clinical followup and asked the following questions. (1) Have you required additional surgery for right/left hip/knee? What was the reason for the surgery (if applicable)? (2) Are you taking antibiotics for your hip/knee? Which antibiotic(s) are you taking (if applicable)? (3) When did you stop taking antibiotics for your hip/knee (if applicable)?

We defined treatment success as infection control. Infections were considered controlled if serum inflammatory makers (ESR and CRP) had normalized and there were no clinical signs or symptoms of infection. Controlled infections included both patients in whom all antibiotics were ultimately discontinued and those kept on long-term prophylactic antibiotic therapy. Treatment failure was defined as recurrence of infection requiring additional surgery or clinically apparent infection diagnosed with a positive aspiration or persistently elevated inflammatory markers and treated with long-term antibiotic suppression.

## Results

Two of the 20 patients had persistent infection at last followup (Table 3). There were no failures in the acute postoperative group (0/2). There were two failures in the acute hematogenous group (2/18), both in patients with infected total knee arthroplasties. One failure occurred in a 91-year-old male with rheumatoid arthritis receiving prednisone and hydroxychloroquine therapy. This patient's inflammatory markers remained elevated postoperatively (CRP = 166, ESR = 80 at one-year followup). He also had an episode of superficial erythema and swelling at 3 months postoperatively controlled successfully with a ten-day course of intravenous vancomycin. Aspiration of the joint has not been attempted since the débridement. The patient declined further surgery and his infection has been successfully suppressed with long-term oral antibiotics (minocycline). The other treatment failure occurred in a 70-year-old obese female with type II diabetes mellitus and chronic lower extremity cellulitis. This patient's inflammatory markers remained elevated, and a knee aspiration performed seventeen months after débridement was

abnormal (26,000 nucleated cells and 95% polymorphonucleocytes). Cultures of the aspirate were negative; however, it is of note that the patient was receiving penicillin V at the time of the aspiration. This patient's infection has been successfully suppressed with long-term antibiotic therapy (penicillin V). Neither patient has yet required additional surgical treatment for their infections.

Of the 18 patients without evidence of persistent infection, 10 patients were no longer on antibiotics. These patients were on intravenous and oral antibiotics for an average total of 9.0 months (range, 1.2–21.6 months). Average followup for these patients since all antibiotics had been discontinued was 45.7 months (range, 16.2–75.3 months). Inflammatory markers returned to normal for all patients. Postoperative inflammatory markers were not available for one patient; however, she has been off all antibiotics for six years and has not required additional surgery for her knee. Eight patients were considered to be compromised hosts (Table 4) and were kept on prophylactic long-term antibiotic therapy. The average followup from the time of débridement for these patients was 28.7 months (range, 13.8–53.5 months). There have been no local or systemic complications secondary to long-term antibiotic use.

**Table 4.** Selected comorbidities and medications of patients on long-term antibiotics

Patient	Age (years)	Comorbidities/medications
1	28	Acute lymphocytic leukemia, status-post bone marrow transplant, chronic graft versus host disease; medications: chronic prednisone; also on chronic penicillin V, chronic trimethoprim/sulfamethoxazole before periprosthetic joint infection
8	72	History of lung cancer, multiple myeloma, chemotherapy
9	77	Age; patient requested long-term suppression for fear of recurrence of infection
10	80	Age; history of prostate cancer status-post radiation, radiation proctitis
11	63	Chronic lower extremity lymphedema; patient requested long-term antibiotics
15	78	Extranodal marginal zone B cell non-Hodgkin's lymphoma, Sjogren's syndrome, myelodysplasia with neutropenia and thrombocytopenia
16	51	Status-post splenectomy and cadaveric kidney transplant; medications: azathioprine, prednisone; also on chronic trimethoprim/sulfamethoxazole before periprosthetic joint infection
17	68	Recurrent B cell non-Hodgkin's lymphoma, metastatic renal cell carcinoma status-post nephrectomy, metastatic Merkel cell carcinoma; brain metastases discovered postoperatively

The two treatment failures in the study group had a symptom onset to débridement duration of 12 and 16 days (Table 3).

## Discussion

Due to the unsatisfactory infection control rates of débridement with component retention of acute periprosthetic joint infections reported in the literature (Table 1), a new treatment protocol was implemented at our institution involving a two-stage débridement with the implantation of antibiotic cement beads at Stage I. The purpose of this review was to determine our infection control rate with this procedure, the number of patients who received long-term antibiotic therapy, and the effect of infection duration on infection control rate.

This retrospective study has several important limitations, including a limited followup period, use of a historical control group, lack of inflammatory marker levels at the last followup for all patients, and potential bias in patient selection. However, all patients who presented with an acute infection were treated with this protocol, thereby reducing selection bias. The study sample size was also small ( $n = 20$ ), however acute periprosthetic infections are a rare complication and the present study compares favorably to most published reports of acute periprosthetic joint infections (Table 1) in terms of sample size. Finally, numerous factors influence the chance of treatment controlling periprosthetic joint infections. These include: (1) host status; (2) symptom onset to débridement interval; (3) pathogen; (4) débridement technique; (5) antibiotic regimen; and (6) whether or not long-term antibiotic therapy was used. However, owing to the small number of treatment failures (two treatment failures occurred in patients staged as II-B-2 and II-C-2 hosts), we are unable to draw conclusions regarding the effect of host status, as classified by the system of McPherson et al. [15, 16], on treatment outcomes. Nevertheless, when reporting treatment outcomes of periprosthetic joint infections, we believe it essential to include these data for all patients to provide the most accurate description of the treatment technique and host characteristics. Inclusion of these data allows for better comparison of data with other studies and also allows for better comparison of subgroups of patients (eg, 'B-hosts').

Historically, the average success rate of retention débridement for the treatment of acute periprosthetic infections has ranged from 24–100% [3, 4, 8, 9, 11, 12, 14, 17, 19, 21–23, 27–29] (Table 1). The data presented here compare favorably, with successful infection control in 18 out of 20 patients. This protocol adds to the length of hospital stay and cost compared to a single débridement

and there may be extra morbidity associated with a second surgical procedure. However, we believe that the improved success rate of this technique more than offsets the hospital stay, cost and morbidity associated with managing a failed débridement. Further research is required to analyze the individual contribution of host status, débridement technique, local depot antibiotics, and combination antibiotic therapy on treatment outcomes.

Of the 18 successfully treated infections, 10 are no longer on antibiotics. Eight patients were treated with prophylactic long-term antibiotics. These patients were kept on long-term antibiotics due to compromised host status (Table 4) or the impact a recurrent infection would have on the patient's health. In these instances, we believed the risks of long-term antibiotic treatment were acceptable when weighed against the consequences of a recurrent infection. We believe it would be inappropriate to consider these patients as "treatment failures," since they never displayed evidence of persistent infection.

Prolonged infection duration is associated with increased biofilm formation and potential for deep osteomyelitis. It is unknown how quickly a clinically meaningful biofilm formation can form; however, retention débridement is not typically recommended if the interval between infection onset and débridement is greater than 28 days [11, 22]. Furthermore, various studies have provided evidence of improved outcomes if the débridement is performed within 3 weeks [13], 2 weeks [3, 26, 28], or 1 week [8] from infection onset. Of the 20 patients in our series, 16 underwent débridement within 1 week of infection onset. Two patients were treated at an interval of 10 days, one patient at 12 days, and the final patient at 16 days. The two treatment failures in the study group had a symptom onset to débridement duration of 12 and 16 days (Table 3). However, because there were only three patients treated with an infection duration between 11 and 28 days, we cannot comment on treatment efficacy for this subset of patients who have symptoms for greater than 10 days.

Successful infection control in 18/20 patients treated with this technique compares favorably with historical infection control rates. With proper patient selection, this technique is effective for the treatment of acute periprosthetic total joint infections.

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